College of Tropical Agriculture
and Human Resources
University of Hawai'i at Mānoa

Plant Disease
July 2012
PD-90

Powdery Mildew of Papaya in Hawai'i

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Papaya (*Carica papaya* L.) is a large, herbaceous plant native to tropical America. By 1616, it was grown widely throughout the warm climates of Central and South America, the West Indies, southern Mexico, the Caribbean, and Southeast Asia (Perseley 2003). The raw pulp of the sweet yellow or reddish-orange ripe fruits is eaten fresh, and the green, immature fruits are used in salads or cooked and used as a squash-like ingredient.

Hawai'i is the leading producer of papaya in the United States, with approximately 526 ha (1,300 acres) harvested in 2009 (USDA NASS 2010). Although Hawai'i's papayas comprise less than 1% of the global market, the state's sale of fresh and processed fruit earned over US$11 million in 2010 (USDA 2011). This made papaya one of the top crops in the state. Hawai'i currently exports papayas to the U.S. mainland, Canada, and Japan.

Powdery mildew of papaya fruits and leaf petioles.

The Puna district on the island of Hawai'i grows 92% of the papayas in the state. With the area's high annual rainfall (280 cm/100 in) and rocky soils, conditions for this crop are optimum. The well-drained soil is important, as papaya is susceptible to root diseases, especially in heavier soils with a high clay content. In high-rainfall areas plants do not need irrigation once the seedlings are established, while in areas in Hawai'i with lower rainfall, growers use drip irrigation.

Important diseases of papaya in high-rainfall areas of Hawai'i include Phytophthora blight and anthracnose, both of which cause severe fruit rots. Other plant pathogens, arthropods, and nematodes attack papaya and may cause significant damage (Constantinides 2008). A persistent and common threat to both home gardeners and commercial farmers is powdery mildew. This fungal disease of papaya leaves and fruit causes premature defoliation, reduced yields, and lower sales due to downgraded fruit or fruit not fit to harvest. In this article we describe the symptoms and disease cycle of powdery mildew on papaya and suggest integrated practices for effective management of the disease in Hawai'i.

Pathogen

Powdery mildew on papaya was first reported from Brazil in 1898. The disease now occurs almost everywhere papaya is grown, including Hawai'i, Brazil, Taiwan, Puerto Rico, the Dominican Republic, Haiti, Jamaica, Trinidad, Florida, and Australia.

Papaya is host to a dozen species of fungi that cause powdery mildew (Tsay et al. 2011). In Hawai'i the disease is caused by the pathogen commonly known as *Oidium*

Published by the College of Tropical Agriculture and Human Resources (CTAHR) and issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, under the Director/Dean, Cooperative Extension Service/CTAHR, University of Hawai'i at Mānoa, Honolulu, Hawai'i 96822.

Powdery mildew negatively affects the marketability of papaya fruits.

Most of the fruits on a given plant may show symptoms of powdery mildew.

caricae (=*Erysiphe cruciferarum*), which was officially renamed *O. caricae-papayae* (Species Fungorum 2012). The infective conidia are hyaline and barrel-shaped microscopically, white and granular macroscopically, and usually produced in chains of five or more.

Biology and Ecology

Powdery mildew of papaya thrives in humid areas with warm days and cool nights, such as north Kona on the island of Hawai'i. Spores of the pathogen, which can germinate in 10–12 hours, are mainly dispersed by wind currents. Low light levels, high humidity, moderate temperatures (64 to 90°F, 18 to 32°C), and moderate rainfall (60 to 100 in, 1,500 to 2,500 mm per year) enhance disease development (Ooka 1993). *Oidium caricae* is an obligate parasite, needing a living host to complete its life cycle.

Symptoms

Powdery mildew infects papaya plants regardless of their age, but seedlings grown in greenhouses are especially susceptible, with apical tissues often destroyed. The disease frequently infects immature leaves but can also attack unripe fruits. The powdery mildew also appears on papaya petioles, pedicels, and peduncles.

In the early stages of the disease, the undersides of leaves are speckled with small, water-soaked spots that become powdery patches of mycelium and spores. The infections are usually concentrated near the leaf veins. The white patches are from 1–6 cm in diameter, with corresponding yellowish-green spots on the upper leaf surface. The mildewed areas grow in size and coalesce, causing increasingly severe yellowing between the veins. In some cases the spore-forming mycelium will wrap around the leaf edge and grow on the upper leaf surface and petioles.

As the disease progresses, severely infected leaves become necrotic and appear scorched. They curl and fall from plants prematurely. Mildew on immature fruit begins as circular patches of white mycelium and spores that can coalesce and cover the entire fruit. As the fruit ripens, the fungus may disappear, leaving behind grey scars. The scars restrict growth of the underlying tissue, resulting in deformed fruit. The deformed fruit is edible but has little or no value in the market.

Cultural Management

Integrate the following cultural practices with the proper pesticides to achieve the best control of powdery mildew.

- Select a site for cultivation that has warm temperatures, low relative humidity, and no extreme differences in daytime and nighttime air temperatures.
- Plant rows parallel to the prevailing trade winds to increase air movement in the canopy.
- Do not irrigate with overhead sprinklers. This increases the relative humidity in the plant canopy. Although powdery mildew is inhibited by water on papaya leaves and fruit, the resulting humidity promotes infection and disease development.
- Periodically remove and destroy heavily mildewed leaves; do not compost the material.
- Ensure adequate nutrition but avoid excessive nitrogen, which can cause a flush of succulent, vulnerable plant growth.

Fungicides

There are several fungicides registered for powdery mildew of papaya in Hawai‘i (see Table 1). Organic growers may use elemental sulfur and potassium bicarbonate, which are both OMRI listed. When using a fungicide, always read and obey the label.

Powdery mildew is visible here on the underside of a papaya leaf. Sprays of contact fungicides such as elemental sulfur must cover this leaf surface.

Table 1. Pesticides registered for control of powdery mildew of papaya in Hawai‘i.

Trade Name	Active Ingredient (%)	Formulation
Abound® Flowable Fungicide	Azoxystrobin (22.9%)	Suspension concentrate
Prev-Am® Ultra	Sodium tetraborohydrate decahydrate (0.99%)	Emulsifiable concentrate
Companion®	*Bacillus subtilis* (GB03) (0.03%)	Emulsifiable concentrate
StorOx® Broad Spectrum	Hydrogen dioxide (27%)	Soluble concentrate
Biocover™	Mineral oil (98%)	Fluid
Rally® 40WSP	Myclobutanil (40%)	Water-soluble packets
Kaligreen®	Potassium bicarbonate (82%)	Water-soluble powder
Drexel Sulfur 90W	Elemental sulfur (90.0%)	Wettable powder/dust
Flint®	Trifloxystrobin (50%)	Soluble concentrate
Procure® 480SC	Triflumizole (42.14%)	Soluble concentrate

Acknowledgements

The authors thank Fred Brooks and Ty McDonald of UH-CTAHR for their thoughtful reviews of this manuscript and Mike Kawate of UH-CTAHR for providing additional information.

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